/CDF/ANAL/EXOTIC/CDFR/6571

Combined results of searches for first generation leptoquarks

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Abstract

We report on the combination of the searches for first generation scalar leptoquarks performed using 72 pb^{-1} of Run II data. First we combine the results of the searches in the channels eejj[1] and eνjj[2] are combined obtaining an upper limit on the production cross section as a function of the leptoquark mass and the branching ratio β= Br(LQ→eq) which gives competitive result for $\beta > 0.3$. We then combine the above 2 channels with the ννjj[3] channel result and obtain better limit than the individual channels in the low β region ($\beta < 0.5$).
By comparison with the theoretical calculations[4] of the cross section we set a lower limit on m(LQ) as a function of β.

Introduction

Searches for pair produced first generation LQ have been performed using the first RunII data in three channels:

- **eejj** – This search gives an upper limit optimal for a branching ratio β= Br(LQ→eq). = 1;
- **e**n**jj** – This search gives the highest limit optimal for a branching ratio β= Br(LQ→eq). = 0.5;
- nn**jj** – The optimal limit is obtained for β= Br(LQ→eq). = 0.0.

In Figure 1 the exclusion regions as function of β obtained from the single channel analysis eejj and eνjj are plotted.

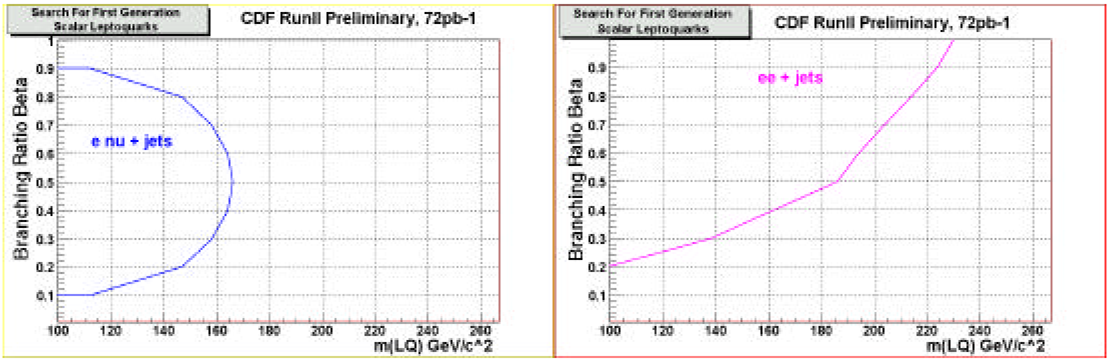

Figure 1 – Exclusion regions as a function of Br(LQ®eq) obtained from the single e njj and eejj channels. The areas at the left of the curves are excluded at 95% CL.

This note presents 2 results: the combination of the 2 channels eejj and eνjj, and the combination of all three possible decay channels. The results are combined using a procedure based on a Bayesian approach[5], which takes into account the correlations in the systematic uncertainties.

Method

To calculate the limits combining all the available leptoquarks decay channels we have used a Bayesian approach. A joint likelihood has been formed from the product of the individual channels likelihood. For each mass we simulated 10K pseudo-experiments, smearing the calculated number of background events and the estimated number of signal events by their respective total uncertainties. The searches in the eejj and eνjj channel use common criteria and sometime apply the same kind of requirements (for example on the tight electron identification) so the uncertainties in the acceptances have been considered completely correlated (which gives the most conservative limit). When calculating the limit combination including also the ννjj channel the uncertainties in the acceptances have been considered uncorrelated.

Results

The results of the combination for first generation scalar leptoquarks are presented in Figure 2, for the 2 cases:

- ee jj and eνjj combination
- eejj, eνjj,ννjj combination

In Figure 3 we report the cross section upper limit compared with the theoretical prediction × branching ratio as function of the leptoquark mass for 2 values of β (0.5 and 1) in the case only two channels are combined. At the intersection point the mass limit is derived.

In Figure 4 we report the cross section upper limit compared to the theoretical cross section in the case where all three channels were combined, for different values of β.

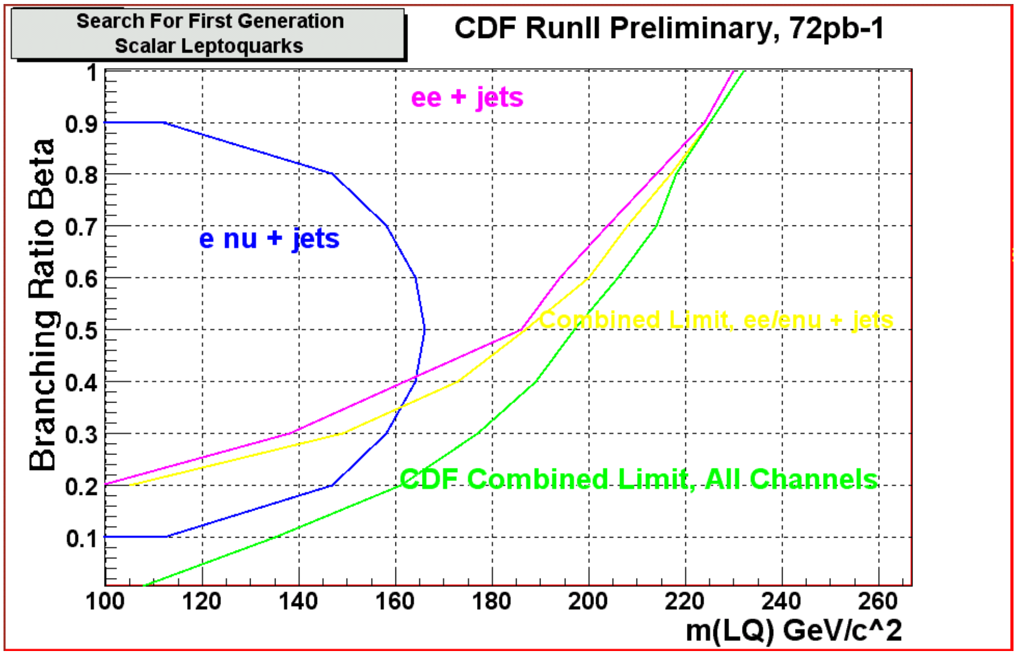

Figure 2 – Exclusion regions as a function of Br(LQ®eq) obtained from the single e njj and eejj channels, their combination (yellow curve) and combination with the nnjj channel (green curve). The areas at the left of the curves are excluded at 95%CL.

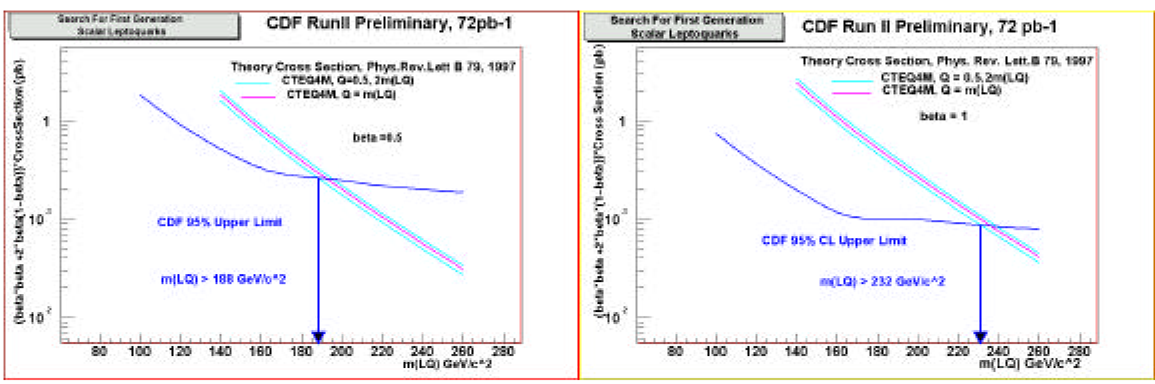

Figure 3 – CDF 95% Upper Limit on the leptoquark cross section as a function of the leptoquark mass, in the case where eejj and e njj channels are combined. At the intersection with the theoretical prediction an upper limit on the mass is derived The theoretical cross section is multiplied by a factor $(b^2 + 2b(1-b))$.

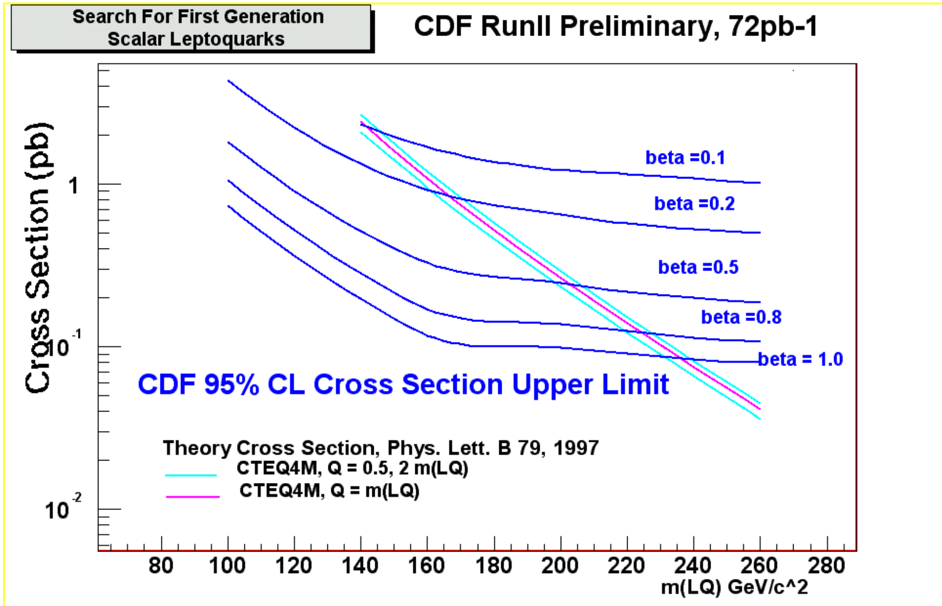

Figure 4 - – CDF 95% Upper Limit on the leptoquark cross section as a function of the leptoquark mass, in the case where eejj, enjj and nnjj channels are combined. At the intersection with the theoretical prediction an upper limit on the mass is derived The theoretical cross section is multiplied by a factor (b^2 +2b(1-b) +$(1-b)^2$)=1.

In Table 3 we report the combined 95% CL cross section limits for different LQ masses and for some values of β. The combination is performed also for β= 1, since the eνjj analysis has a non-zero efficiency for di-electron events, when one of the electrons is not in the detector acceptance.

M(LQ) GeV/c^2	β=0.2	β=05	β=1.0
	σ_{95} (pb)	σ_{95} (pb)	σ_{95} (pb)
100	4.5	1.8	0.8
140	1.3	0.5	0.2
160	0.9	0.3	0.12
200	0.7	0.24	0.098
220	0.6	0.22	0.091
240	0.5	0.20	0.083

Table 1 – 95% CL combined cross section limits for different values of b, obtained from the combination of only eejj and e njj channels (case mass = 220, 240 GeV/c^2) and from all three eejj, e njj and nnjj channels (mass < 220 GeV/c^2)

In Table 2 we report the 95% CL upper limit on the leptoquark mass in the case where only 2 channels are combined or all three. As we can see, the limits are of similar magnitude for β > 0.5, while for lower values of β the inclusion of the third channel improves greatly the limit.

β	Mass 95% Upper Limit(GeV/c^2) 2 channels	Mass 95% Upper Limit(GeV/c^2) 3 channels
0.1	135	<100
0.2	161	105
0.3	177	149
0.4	189	173
0.5	197	187
0.6	206	200
0.7	214	208
0.8	218	217
0.9	225	225
1.0	232	232

Table 2 – 95%CL mass upper limits for the combination of 2 channels (eejj, e njj) and three channels (eejj, enjj, nnjj).

Conclusions

We have performed the combination of all the CDF searches for first generation scalar letpoquarks using Run II data. The results are presented for the 2 channels eejj and eνjj combination, and the combination of all three possible decay channels. The results are combined using a procedure based on a Bayesian approach which takes into account the correlations in the systematic uncertainties.
We set 95% CL lower limit for scalar first generation leptoquarks at 161 GeV/c^2 (β =0.2), 197 GeV/c^2 (β =0.5) and 232 GeV/c^2 (β =1.0).

Acknowledgements

I want to thank Lorenzo Moneta for providing me with the code necessary to perform the limit combination. I also thank Federica Strumia and Lorenzo for useful discussion about the combination procedure.

References

1) Search for first generation leptoquarks pair production in eejj, S. Rolli CDF/ANAL/EXOTIC/CDFR/6338, March 2003
2) Search for first generation leptoquarks pair production in eνjj, S. Rolli CDF/ANAL/EXOTIC/CDFR/6436, June 2003

3) Search for First-Generation Leptoquarks in the Jets and Missing Transverse Energy Topology. D. Acosta, K. Konigsberg, A. Moorhead, D. Tsybychev, S.M. Wang. CDF/ANAL/EXOTIC/CDFR/6383
4) Pair Production of scalar LeptoQuarks at the TeVatron, M. Kramer et al., Phys Rev Lett 79, 341, 1997.
5) Combined Results of Searches for Second Generation Leptoquarks, Lorenzo Moneta. CDF/ANAL/EXOTIC/PUBLIC/5790